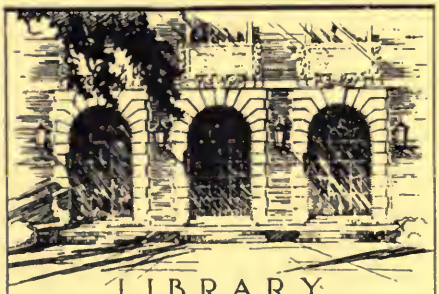

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PROGRAMMED PRODUCTION RESPONSES ON DAIRY FARMS IN NORTHEASTERN ILLINOIS

C. B. Baker, Max R. Langham, Keith G. Cowling

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Urbana, Illinois March, 1965

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PROGRAMMED PRODUCTION RESPONSES ON DAIRY FARMS IN NORTHEASTERN ILLINOIS

MILK PRODUCERS, MILK BUYERS, AND POLICY MAKERS need estimates of the response of milk production to price change. Producers and buyers need such estimates as they decide to expand, drop, or change dairy operations, and as they negotiate prices and other terms of exchange. The policy maker must know the effect of production on market regulation. Both are interested in differences among regions in responsiveness to price change.

In the wake of rapid declines in the number of producers, there remain fewer but larger dairy farms with a distinct trend in these toward greater specialization and mechanization. Production per cow has increased markedly, owing to improved breeding, better quality of feeds, and heavier rates of feeding. All these changes have influenced the relations between milk production and the price of milk, the prices of resources used to produce milk, and the prices of products that compete with dairying for the use of resources on the farm.

In considering this competition for resources on the farm, it should be kept in mind that some resources are committed to the production of milk in amounts that are fixed for a considerable length of time. Milking machines, coolers, and similar equipment are used almost exclusively in milk production. These and many similar items are used longer than a season or a year, or in some cases, longer than a dairy cow's productive life. Such assets, up to their capacity, generate costs that are fixed, with respect to the volume of milk produced, over the entire length of asset life.

Other resources are specialized for use in milk production but are variable over a short time period (e.g., some types of feed and some milk handling supplies). The cost of these resources varies with respect to milk production, and is most important in relation to variation in milk price. To maximize net returns in a given time period requires the milk producer to use variable resources so that their additions to the cost of producing another unit of milk equal the price he receives for that unit of milk. Therefore, a change in milk price would increase or decrease the production of milk by an amount which depends on how much variable costs are increased or decreased in attempts to vary production.

Still other resources are non-specialized. For example, pasture can be used to support non-dairy as well as dairy livestock. Labor used in the dairy enterprise can be used in non-dairy enterprises, and so forth.

Use of these resources to produce milk depends on their relative productivity in alternate uses, the prices of products of the alternative enterprises, and variable cost, with respect to output, of resources specific to these enterprises. Under Illinois conditions, the alternatives are numerous in crop as well as livestock enterprises. Hence factors that affect milk production include prices of alternative products as well as resource prices and resource productivities.

This bulletin reports estimates of the response of milk production in northeastern Illinois to variations in the prices of milk, hogs, beef cattle, labor, and corn.

ANALYTICAL PROCEDURES

Linear programming methods were used to take into account the factors affecting milk production.[1] A model was constructed for each of four types of milk producing farms in the study area. Specifications for the model included resource supplies, alternatives for their use, quantities of resources required per unit of output in each of the alternatives, and, finally, an objective to be maximized subject to constraints imposed by the resource supplies. The objective function is a sum of quantities of output from each alternative, each quantity weighted by a net price postulated for the product in question. Maximizing the objective function, subject to the constraints, generates a farm plan that describes a resource use and output mix that maximizes returns to specified resource supplies. By varying the price of milk and obtaining a new solution for each price, a price-quantity supply relation is obtained, each quantity being an optimum in the sense indicated in this paragraph. Total quantities for a given type of farm were obtained by multiplying quantities for an individual farm by the number of farms of that type in the area. Finally, a supply was estimated for the area as a whole by summing quantities over all types.

Four methodological assumptions are required for models such as those used in this study. (1) For a given production alternative all relations between resource supplies and resource use are linear; production of 1 unit of output presumes the same requirement in resource per unit as does 1,000 units of output. (2) There is a finite set of alternatives and resources that exhausts all possibilities and constraints. (3) Alternatives are independent of each other in terms of resource use; resources required per unit of output in one alternative are in no

[1] For application of these methods to another dairy problem, see K. R. Tefertiller and C. B. Baker, *Selection of Freshening Dates That Will Maximize Dairy Products,* Ill. Agr. Exp. Sta. Bul. 681, January 1962.

way affected by the level of output obtained in any other alternative. (4) Output and resource use are possible in perfectly divisable units; that is, it is possible to change milk production by a single pound, changing the use of cows by a fraction, and so forth.[1]

Each of the linear programming models used in this study is comprised of a set of alternatives. Each production alternative is described by an annual budget of resources required per unit of its activity, and with a price to value the unit of activity. Some resources are entirely used within the year. Some have lives longer than a year. Among the latter, depreciable assets, such as machinery, buildings, breeding livestock, and so forth, are often listed among the constraining resource supplies with budget requirements stated in terms of depreciation per unit of activity per year. Thus a unit of activity is charged with a depreciable resource only at the depreciation rate within the year. The fact that profit maximization is subject to the constraint of a fixed supply of certain resources implies that the solution is a short-run equilibrium. On the other hand, when the rate at which a depreciable source is used is but a small fraction of its total services, the short-run character of the model is substantially modified.

At each of the succession of prices, the quantity of milk generated in a profit-maximizing plan represents a change not from the quantity at the preceding price, but rather a change from the basic situation which simply states the resource supplies. In other words, adjustment to each price, in a succession of prices, is independent of adjustments to any other price in the series of prices. It is important to keep this in mind when reviewing results of the research reported below. No inferences can be made of inter-price adjustments.

Nor can any inference be made about the rate of adjustment to change in price of milk. This is particularly unfortunate because solutions to many problems that require supply-response estimates would be materially helped by estimates of the time-rates of adjustment.[2]

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[1] For a general discussion of these assumptions and their implications, see Robert Dorfman, *Application of Linear Programming to the Theory of the Firm,* University of California Press, Berkeley, 1951. For a discussion of their implications in agricultural applications, see E. R. Swanson, "Programming Optimal Farm Plans," in *Farm Size and Output, A Study in Research Methods,* Southern Cooperative Series Bul. 56, Okla. Agr. Exp. Sta., 1956.

[2] For a beginning on this kind of estimation, using linear programming methods, see Keith G. Cowling and C. B. Baker, "A Polyperiod Model for Estimating the Supply of Milk," *Agricultural Economics Research,* Vol. 15, No. 1, January 1963, pp. 15-23.

THE AREA

In this study we estimate the likely production response to price change of about 3,200 milk producers in a seven-county area of northeastern Illinois. The counties include Boone and Kendall counties, plus five counties immediately adjacent to Cook County: McHenry, Lake, Du Page, Kane, and Will. The 1959 census reports 7,494 commercial farms in this area. Survey data from this study suggest that 3,432 of these farms have facilities for producing milk and that the facilities are used on 3,200 farms. It is estimated that 2,600 sell to Order-41 (Chicago) handlers, the remainder of 600 selling to non-Order-41 handlers within the Illinois part of the Chicago supply area. In any event, our statistics relate to the whole 3,200 producers in the area insofar as production response *rates* are concerned. Where we present numerical estimates of milk *quantities,* those interested in the supply for the Chicago market alone might obtain a reasonably accurate approximation by multiplying each estimate by 0.8125, which is the ratio, 2,600:3,200. Such a procedure presumes that the average non-41 producer supplies the same quantity of milk at a given price as does the average 41 producer.

The area studied is becoming more and more urbanized. Between 1950 and 1958 nearly 200,000 acres (more than 10 percent of the land that was in farms) shifted from agricultural to non-agricultural use in the seven-county area. Land left in agricultural use shifted markedly toward cash grain crops. The area is characterized by hot summers and cool to cold winters. The frost-free season ranges from 160 to 170 days, sufficient for many crops. Precipitation is highly reliable at from 32 to 34 inches, with monthly maximums normally in May and June. Winds prevail from southwest to west in the summer, and from west to the northwest in the winter. Considerable daily fluctuation is observable in wind direction and velocity as well as temperature, humidity, and precipitation.

Such climatic features have yielded fertile soils under lush growth of prairie and timber vegetation. The soils are dark colored, level to moderately sloped, and are moderately to highly productive under intensive cropping. Soils developed under timber vegetation are lighter in color and less productive. There are small areas of steep to very steep slopes, not suited to cultivation. However, most soils in the area are suitable for cultivation with appropriate erosion control practices.

In summary, climatic and soil conditions make possible a wide range of crops and are conducive to important development of live-

stock enterprises. The proximity of the Chicago market provides further advantages for the production of dairy products and, to a more limited extent, fresh vegetables, ornamental shrubs, and flowers.

THE FARMS

Our basic data were obtained from a survey of farms in 54 area segments drawn randomly in the seven-county area. The segments yielded 98 usable schedules from 101 personal interviews of farm operators.[1] With these data, quantities of land, labor, and capital supplies in the form of facilities for crops and livestock, were estimated for farms typical of each of several classes expected to respond differently to changes in prices of milk and other products and factors. The classification was based on degree of specialization in dairying, amount of dairy capacity, and size of farm.

On the basis of our sample, we estimated that 1,634 were specialized dairy farms (see Table 1). These are farms on which no facilities exist for livestock other than dairy animals. We estimated an additional 1,094 farms to be non-specialized dairy farms, but with facilities for 35 or more dairy cows per farm. Of these, 315 had less than 170 crop acres, while 779 had 170 or more crop acres per farm. There were an estimated 472 farms with less than a 35-cow capacity and with less than 170 crop acres.

To complete the classification of farms within the total area, we estimated that 232 had 170 or more crop acres but less than a 35-cow capacity per farm. We also estimated that 4,062 farms had no dairy facilities whatever. All farms in these last two classes are omitted from our present results because our study revealed that they would be an unimportant source of milk at prices likely to exist within the area. We note, however, that the last group includes 2,338 farms with 170 or more crop acres that would find milk a profitable alternative at a blend price of $4.70 per hundredweight or higher and, at such prices, would be an important new source of milk supply.

Specialized dairy farms

The average specialized dairy farm contained 216 acres of land, 188 in crops. The 20 to 25 acres of permanent pasture produced nearly 3,500 animal unit days of summer grazing. The cows were assumed milked in stanchions, since this was the system that was dominant by a wide margin in the surveyed areas. The average silo capacity was

[1] Interviews were conducted by Ritchie Barnett, A. G. Wennmacher, and Donald J. Hunter (crew chief), in June 1959.

Table 1. — Commercial Farms in the Study Area[a] as Reported by the 1959 Census, Distributed by Selected Type and Size Characteristics[b]

Specialized dairy farms			1,634	
Non-specialized dairy farms				
Cow capacity 35 or more				
Cropland 170 or more acres	779			
Cropland less than 170 acres	315			
Total		1,094		
Cow capacity less than 35				
Cropland 170 or more acres[c]	232			
Cropland less than 170 acres	472			
Total		704		
Total non-specialized dairy farms			1,798	
Total, farms with dairy facilities				3,432
Farms without dairy facilities[c]				4,062
Total, all commercial farms				7,494

[a] The study area is a seven-county area of northeastern Illinois, including the counties of McHenry, Lake, DuPage, Kane, Will, Boone, and Kendall.

[b] Distributions of the total are in proportions reported in a random sample of area segments in the seven-county area.

[c] These farms were found to be unimportant sources of milk in relevant ranges of milk prices and are not included in aggregates of milk supplies.

227 tons, in upright masonry structure. Milk cow capacity averaged 36 head.

The labor supply varied a bit within the year, being slightly in excess of one man throughout the year. There were 1,022 hours available in January through March, 771 hours in April through May, 1,378 hours in June through August, 787 hours in September through October, and 700 hours in November through December. The average farm had $21,606 in cash or short-term borrowing capacity, plus $48,000 in borrowing capacity on real estate. Added credit in either category could be generated by addition of assets: short-term, through purchasing or raising additional dairy cows; long-term, by adding to dairy and silo capacity.

Nearly 40 percent of the cropland in the seven-county area is used to produce corn, with another 30 percent or so kept in meadow. The remainder is distributed among small grains and soybeans. Hence, four rotations were budgeted as alternatives for the use of the 188 acres of cropland in the specialized dairy farm. Each rotation includes two consecutive years of corn, followed alternatively by oats (with a legume crop plowed down); oats and legume; soybeans, oats and legume; and oats plus two years of legume. Corn for grain was fertilized at an average per acre of 75 pounds nitrogen, 30 pounds P_2O_5, and 20 pounds K_2O; for silage, 100 pounds nitrogen, 40 pounds P_2O_5, and 105 pounds K_2O. Soybeans were fertilized at 30 pounds P_2O_5, and 35 pounds K_2O per acre. Oats received 35, 15, and 10 pounds per

acre of nitrogen, P_2O_5, and K_2O, respectively; meadow for hay, 45, 30, and 125; meadow pastured, 10, 5, and 10.

The corn crop was allowed to be harvested as grain or as silage, according to proportions required in the profit maximizing organization. Similarly, the meadow was allowed to be harvested as hay or pasture. Corn or hay could be bought or sold.

The choice of the crop system depended not only on the prices of crops that could be sold, but also on the size of herd and the feeding system selected for the herd. Three systems were budgeted as alternatives: a traditional system, with cows pastured and fed hay and grain in off-pasture seasons; a maximum-corn system, with cows fed neither hay nor pasture, the forage being supplied from silage alone; and an intermediate system, wherein cows are fed stored feed the year around, but with hay included in the ration. In each system, four grain:milk feeding ratios were allowed as alternatives: 1:2, 1:2.5, 1:4, and 1:6. Cows were assumed to yield 10,000 pounds of 3.5-percent fat-corrected milk when fed at a grain:milk feeding ratio of 1:4. In summary, milk production could vary by changing the number of cows, by varying feeding intensity, or by varying the feeding system. Finally, a choice was allowed to buy or raise replacement cows.

Non-specialized dairy farms

From Table 2 we note that non-specialized dairy farms vary considerably in resources available to produce milk. The average farm with 35 or more stanchions had a capacity of 51 cows in large crop farms, and 37 in small crop farms. In total acres, the averages were 307 and 164, respectively. These were distributed 269 in crops, and 38 in permanent pasture, for large farms; 136 in crops and 28 in permanent pasture for small farms. The small dairy farms varied little in dairy capacity between large and small crop acreages. The

Table 2. — Resources Available on Typical Non-Specialized Dairy Farms in the Study Area

Class of farm	Cow capacity	Crop acres	Permanent pasture		Labor supply[a]					
			Acres	AUD	Jan.-Mar.	Apr.-May	June-July	Aug.	Sept.-Oct.	Nov.-Dec.
Cow capacity 35 or more										
Crop acres 170 or more	51	269	38	4,700	1,864	1,315	1,659	789	1,397	1,286
Crop acres less than 170	37	136	28	3,500	1,199	997	1,142	553	983	884
Cow capacity less than 35										
Crop acres 170 or more	23	240	34	4,300	1,174	972	1,021	498	937	827
Crop acres less than 170	24	110	24	3,000	987	775	880	437	745	681

[a] Family plus hired labor less requirements for 215 hens on farms with less than 170 crop acres (small farms), and for 365 hens on farms with 170 or more crop acres (large farms).

survey revealed the highest incidence of idle dairy capacity in the case of small dairy farms with large crop acreages. We found that these farms would be an unimportant source of milk at prices within ranges relevant for the Chicago milk market, and accordingly have dropped these 232 farms from all our estimates made below. Likewise, we have omitted analyses made of the farms reporting no dairy facilities (estimated at 4,062) because they produce no milk in profit maximizing plans within relevant price ranges. All future references to "small dairy farms" will include only the 472 farms that are small both in dairy capacity and in crop acreages.

Large dairy farms reported an average hog farrowing capacity of 11 litters, with fattening facilities for 16 litters in the case of those with large crop acreages, and 11 for those with small crop acreages. The average beef fattening capacity for all large dairy farms was 20 head. Large dairy farms with large crop acreages reported on the average, 377 tons of silo capacity; with small crop acreages, 167 tons. The small dairy farms reported an average farrowing capacity of 11 litters and the same capacity for hog fattening. They reported an average capacity for beef fattening of 20 head. Silo capacity was 142 tons, on the average.

For large dairy farms with large crop acreages, cash and other liquid assets were $31,800; for those with small crop acreages, $19,800. For small dairy farms the sum available was $14,400. Borrowing capacity for non-real estate assets could be generated by acquisition of certain assets, such as dairy cows. Borrowing capacity on real estate was $65,000, $44,000, and $27,000, respectively, and could be used to finance additions to farrowing, feeding, or dairy capacity, or to construct additional silo capacity.

THE MODELS

In addition to milk, prices were varied, on specialized farms, for corn and for labor; on non-specialized farms, for hogs, and, in the case of one type, beef cattle. We turn next to a description of budgets considered for the specialized dairy farms.

Specialized dairy farms

At fertility levels indicated above, corn was assumed to yield 81 bushels of grain, or 14.5 tons of silage per acre; oats, 59 bushels per acre, or, in corn equivalents, 29.5 bushels; soybeans, 33 bushels per

Table 3. — Budgets of Crop Alternatives for Specialized Dairy Farms (Recommended Fertility Levels)[a]

	Corn-corn-oats	Corn-corn-oats-legume	Corn-corn soybeans-oats-legume	Corn-corn-oats-legume-legume
	(per acre)			
Cropland, acres	1	1	1	1
Corn, bushels	−54.00	−40.50	−32.40	−32.40
Meadow, tons	−.20	−.87	−.70	−1.28
Corn equivalent, bushels	−9.80	−7.40	−5.90	−5.90
Hours labor: Jan.-Mar.	.90	.70	.60	.60
Apr.-May	1.70	1.30	1.60	1.10
June-July	1.70	1.29	1.19	1.08
August	.30	.21	.21	.22
Sept.-Oct.			.40	
Nov.-Dec.			.20	
Cash	19.71	15.03	15.15	12.22
Profit	−19.71	−15.03	−1.69	−12.22

[a] Negative signs in the table denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column head. In the last row, the numbers indicate the amount by which cash profit is reduced by each acre of rotation.

acre; and meadow, 180 animal unit days of grazing, or 2.9 tons of hay per acre. Thus budgets for the four crop alternatives on specialized dairy farms are as indicated in Table 3. In the accounting procedure common in linear programming models, it is convenient to show the amount of cash production costs as profit from crops used for feed. Where soybeans are in the rotation, these cash costs are reduced, in the profit row (last row in Table 3), by the value of soybeans per rotation acre.

In Table 4, we give budgets that describe harvesting alternatives for corn and meadow. Again, the contribution to profit is shown as less than zero, because the harvest activities result in feed resources instead of cash. However, we allowed corn to be sold (at $1.08 per bushel) as an alternative to feeding. Hence there is a corn selling activity that results in a positive contribution to profit. The difference of 8 cents per bushel in the price of corn bought and corn sold approximates the cost of marketing between the farm and the point of first sale or purchase. With the purchase of a bushel of corn, we assume the operator's ability to borrow is increased by 58 cents, half the price paid for a bushel of corn.

The model includes 12 milking activities, four alternative rations in each of the three alternate systems of feeding (see Table 5). Within feeding systems, labor requirements are the same, regardless of ration

Table 4. — Crop Harvest and Buying and Selling Alternatives for Specialized Dairy Farms[a]

	Harvest corn for 100 bushels of		Harvest meadow for 10 tons of		Buy corn (bushel)	Sell corn (bushel)
	Grain	Silage	Hay	Pasture		
Corn, bushels	100	100				
Meadow, tons			10	10		
Pasture, animal unit days				−625		
Hay, tons			−10			
Corn equivalent, bushels	−100				−1	−1
Corn silage, tons		−17.90				
Silo capacity, tons		17.90				
Hours labor: Apr.-May			1.50			
June-Aug.			21.00			
Sept.-Oct.	2.92	17.40	7.50			
Nov.-Dec.	2.92					
Cash	4.00	24.00	68.60	7.60	1.16	
Non-real estate credit					−.58	
Profit	−4.00	−24.00	−68.60	−7.60	−1.16	1.08

[a] Negative signs denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column head. In the last row, the numbers indicate the amount by which cash profit is reduced or increased by each unit of activity.

Table 5. — Budgets of Milking Alternatives for Specialized Dairy Farms[a]

	Grain : milk ratios of			
	1:2	1:2.5	1:4	1:6
	(per cow)			
A. Traditional system				
Pasture, animal unit days	160	160	170	180
Hay, tons	1.08	1.31	1.54	1.59
Corn equivalent, bushels	81.44	64.00	36.60	22.60
Corn silage, tons	3.24	3.93	4.62	4.77
Milk, hundredweight	−111.24	−109.10	−100.00	−92.10
Profit	−29.04	−19.93	−7.19	−1.13
B. Maximum corn system				
Pasture, animal unit days	0	0	0	0
Hay, tons	0	0	0	0
Corn equivalent, bushels	75.48	59.30	33.90	20.95
Corn silage, tons	14.16	15.54	17.40	18.18
Milk, hundredweight	−111.24	−109.10	−100.00	−92.10
Profit	−61.10	−48.94	−31.44	−22.94
C. Intermediate system				
Pasture, animal unit days	0	0	0	0
Hay, tons	1.10	1.30	1.45	1.52
Corn equivalent, bushels	81.44	64.00	36.60	22.60
Corn silage, tons	10.62	11.64	13.05	13.62
Milk, hundredweight	−111.24	−109.10	−100.00	−92.10
Profit	−46.91	−37.80	−25.06	−19.00

[a] Negative signs denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column head. In the profit rows, numbers indicate the amount by which cash profit is reduced by each unit of activity.

fed. In the "traditional" system, 19.5 hours of labor are required per cow in the months of January through March, 10.44 in April through May, 7.8 in June through July, 3.94 in August, 7.8 in September through October, and 12.84 in November through December. In the "maximum corn" system, the corresponding requirements are 17.05, 10.62, 9.83, 4.96, 9.86, and 11.38; in the "intermediate" system, 17.55, 10.95, 10.17, 5.13, 10.20, and 11.70. For all three systems there is a requirement at each ration of 1 unit of dairy capacity, and 1.23 head of dairy cows per head of cow milked. The latter requirement reflects the rate of replacement.

Feed requirements vary within as well as among feeding systems. So also do contributions made to profit. The amount of milk yielded per cow is assumed the same for a given ration, regardless of the feeding system. Milk is sold at prices ranging from $2.70 to $5.10 per hundredweight. The prices were varied within this range at intervals of 40 cents per hundredweight.

In Table 6 we present budgets that describe the alternatives of replacing milk cows by purchase or by raising replacements, and of selling cows. To purchase replacements requires only cash, whereas to raise replacements requires feed and labor as well as cash. Annual costs, shown in the profit row, are defined as the cash outlay for the cow, multipled by the replacement rate (.23), plus .07 of half the pur-

Table 6. — Budgets for Replacing Dairy Cows on Specialized Dairy Farms[a]

	Replace milk cow by	
	Purchase	Raising
	(per cow)	
Pasture, animal unit days		180
Hay, tons		1.84
Corn equivalent, bushels		25.40
Corn silage, tons		5.52
Hours labor: Jan.-Mar.		14.02
Apr.-May		7.42
June-July		3.71
August		2.06
Sept.-Oct.		4.95
Nov.-Dec.		9.07
Milk cows, head	−1	−1
Cash	320.00	61.45
Non-real estate credit	−160.00	−160.00
Profit	−84.80	−51.08

[a] Negative signs denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column head. The numbers in the last row indicate the amount by which cash profit is reduced by each unit of activity.

chase price in case of purchased replacement, or minus $10.37, the value of manure credit, in the case of a raised replacement.

The model is completed by the alternatives shown in Table 7, which permit capacity to be expanded for the dairy enterprise and for silage. Finally, borrowing is made possible on real estate and non-real estate assets, at a cost of 6 cents and 8 cents respectively, per dollar per year.

Non-specialized dairy farms

For non-specialized dairy farms, a rotation of corn-soybeans-oats-legume was added to the four listed above for the specialized dairy farm. Additionally, all five rotations could be fertilized at either the levels indicated above for the specialized dairy farm, or at a lower level equal to the average of nutrients supplied in the area: corn for grain — 65 pounds of nitrogen, 25 pounds of P_2O_5, and 15 pounds of K_2O; corn for silage — 90, 35, and 90 pounds respectively; for oats — 35, 15, and 10 pounds respectively; for soybeans — 0, 25, and 30 pounds; meadow for pasture — 10, 5, and 10; and meadow for hay — 40, 25, and 115 pounds, respectively.

For non-specialized farms, labor required per acre for the various rotations is slightly less on the farm with large dairy capacity and crop acreage (see Table 8). Budgets for crop alternatives otherwise are identical as between specialized dairy farms and the large dairy farms with large crop acreages.

For lower (average) fertility levels, the crop budgets are given in Table 9. They result in lower yields, thus smaller additions to feed supply, and lower cash requirements, as shown in cash and profit rows

Table 7. — Investment Alternatives and Borrowing Activities on Specialized Dairy Farms[a]

	Capacity investment		Transfer	
	Dairy	Silo	Cash to real estate credit	Non-real estate credit to cash
	(head)	(130 T.)	(dollars)	(dollars)
Silo capacity, tons	−1	−130		
Dairy capacity, head				
Cash			1	−1
Non-real estate credit				1
Real estate credit	238.93	1,900	−1.06	
Profit	−25.08	−163.65		−.08

[a] Negative signs denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column heads. The numbers in the last row indicate the amount by which cash profit is reduced by each unit of activity.

Table 8. — Budgets of Crop Alternatives for Non-Specialized Large Dairy Farms (With Dairy Capacity of 35 or More Stanchions) and Large Crop Acreage (170 or More) at Recommended Fertility Levels[a]

	Corn-soybeans-oats-legume	Corn-corn-oats	Corn-corn-oats-legume	Corn-corn-soybeans-oats-legume	Corn-corn-oats-legume-legume
			(per acre)		
Cropland, acres	1	[b]	[b]	[b]	[b]
Corn, bushels	−20.20	[b]	[b]	[b]	[b]
Meadow, tons	−.87	[b]	[b]	[b]	[b]
Corn equivalent, bushels	−7.40	[b]	[b]	[b]	[b]
Hours labor: Jan.-Mar.	.60	.8	.6	.5	.5
Apr.-May	1.40	1.6	1.2	1.5	1.0
June-July	1.00	1.6	1.2	1.1	1.0
August	.10	.3	.2	.2	.2
Sept.-Oct.	.50			.4	
Nov.-Dec.	.30			.2	
Cash	13.32	[b]	[b]	[b]	[b]
Profit	3.61	[b]	[b]	[b]	[b]

[a] Negative signs denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column heads. The numbers in the last row indicate the amounts by which profit is increased or decreased per acre of rotation.
[b] Coefficients are the same as in Table 3.

of Table 9. None of these alternatives with lower fertilizer requirements were selected in profit maximizing plans, thus supporting the hypothesis that farms on the average still fall short of maximizing returns from fertilizer use.

Table 9. — Budgets of Crop Alternatives for Non-Specialized Large Dairy Farms With 170 or More Crop Acres, Average Fertility Levels[a]

	Corn-corn-oats	Corn-corn-oats-legume	Corn-soybeans-oats-legume	Corn-corn-soybeans-oats-legume	Corn-corn-oats-legume-legume
			(per acre)		
Cropland, acres	1	1	1	1	1
Corn, bushels	−46.67	−35.00	−17.50	−28.00	−28.00
Meadow, tons	−.19	−.81	−.81	−.65	−1.19
Corn equivalent, bushels	−9.20	−6.90	−6.90	−5.50	−5.50
Hours labor			(Same as in Table 8)		
Cash	18.48	14.12	12.67	14.30	11.49
Profit	−18.48	−14.12	1.61	−2.88	−11.49

[a] Negative signs denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column heads. The numbers in the last row indicate amounts by which profit is increased or decreased per unit of activity.

Table 10. — Harvest Alternatives for Crops on Non-Specialized Large Dairy Farms With 170 or More Crop Acres[a]

		Harvest corn for 100 bushels of		Harvest meadow for 10 tons of hay[b]
		Grain[b]	Silage[b]	
Hours labor:	Apr.-May			1.45
	June-July			18.85
	August			1.45
	Sept.-Oct	2.78	16.8	7.25
	Nov.-Dec	2.78		

[a] Each coefficient indicates a labor requirement per unit of crop activity.
[b] Requirements other than those shown are the same as indicated in Table 4.

In Table 10 we show budgets for harvesting alternatives that are given for the non-specialized dairy farm with large dairy capacity and large crop acreage. They are the same as for specialized dairy farms aside from slight changes in labor requirements for corn harvested for grain or silage and meadow harvested as hay. The non-specialized dairy farms were allowed the same option as the specialized dairy farms to buy and sell corn. Since the budgets for doing so are the same as given in Table 4, they are not repeated in Table 10.

For non-specialized dairy farms only one dairy feeding system was used. It is comparable to the "traditional" system reported in Table 5, except that it makes use of hay equivalents on non-specialized farms in place of hay and corn silage, as in the case of the specialized dairy farms. Also, for non-specialized farms, the most intensive feeding ratio (1:2) was not included among the feeding alternatives.

Other than for these exceptions, the budgets for feeding alternatives are identical to those for specialized farms as given in Table 5 and in the accompanying text.

As with specialized dairy farms, a choice was allowed between buying and raising milk cow replacements. The $84.80 (Table 6) is comprised of 23 percent (the annual depreciation rate) of $320 plus 7 percent (the non-real estate loan interest rate) of $160 (the average investment in a dairy cow).

The budget for raising a milk cow replacement on the non-specialized dairy farm required 3.67 tons of hay equivalents, in place of the 1.84 tons of hay and 5.52 tons of corn silage, on the specialized dairy farm (see Table 6). As with the specialized farm, to raise a replacement reduced profit by $51.08 — cash costs of $61.45, less manure credits of $10.37. Salvage value of the cull cow is credited to the dairy milking activities.

To invest in expansion of dairy or silo capacity on the non-specialized farm requires the same budgets that are shown in the first two columns of Table 7. The borrowing activities, shown for specialized farms in the last two columns of Table 7 are also the same for non-specialized farms. Hence these budgets are not repeated here.

The greatest difference between specialized and non-specialized dairy farms lies in the production of livestock other than dairy. Nine alternatives are provided for hogs alone: 1-, 2-, and 4-litter systems either on pasture or in confinement, and, in addition, the purchase of feeder-pigs in spring or in fall, the latter with either cash or with receipts from the sale of hogs from the spring pig crop. Budgets for the different litter systems are provided in Table 11 for pigs raised on pasture, and in Table 12 for pigs raised in confinement. Table 13 contains budgets for the purchase of feeder-pigs. In all budgets, the contributions to profits are shown to be negative, since the activities simply produce market hogs (in hundredweight) for a hog supply, out of which sales were made at prices varying from $11.60 to $19.10 per hundredweight, at intervals of $1.50 per hundredweight.

Table 11. — Budgets for Hogs Raised on Pasture, Non-Specialized Large Dairy Farms With 170 or More Crop Acres[a]

	Units of hogs raised on pasture (per year) in		
	1-litter system	2-litter system	4-litter system
Pasture, animal unit days	65	90	155
Corn equivalent, bushels	113.43	217.39	434.79
Hours labor: Jan.-Mar.	6.99	19.21	31.53
Apr.-May	9.69	8.58	16.95
June-July	2.25	6.16	22.23
August	2.46	3.08	6.44
Sept.-Oct.	4.38	10.13	16.29
Nov.-Dec.	3.85	7.87	16.62
Farrowing capacity, litter	1	1	1
Fattening capacity:			
Spring hogs, litter	.75	1.00	1.75
Fall hogs, litter	1.00	1.00	1.75
Cash	128.05	192.56	382.12
Non-real estate credit	−67.58	−104.12	−208.25
Hogs, hundredweight	−15.37	−33.00	−64.40
Profit	−119.06	−175.02	−347.04

[a] Negative signs denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column heads. The numbers in the last row indicate amounts by which profit is decreased by a unit of activity.

Table 12. — Budgets for Hogs Raised in Confinement, Non-Specialized Large Dairy Farms With 170 or More Crop Acres[a]

	Units of hogs raised in confinement (per year) in		
	1-litter system	2-litter system	4-litter system
Pasture, animal unit days	35	35	70
Corn equivalent, bushels			
Hours labor: Jan.-Mar.			
Apr.-May			
June-July			
August			
Sept.-Oct.	(Same as in Table 11)		
Nov.-Dec.			
Farrowing capacity, litter			
Fattening capacity:			
Spring hogs, litter			
Fall hogs, litter			
Cash	144.74	226.55	450.11
Non-real estate credit	(Same as in Table 11)		
Hogs			
Profit	−134.46	−206.37	−409.75

[a] Negative signs denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column heads. The numbers in the last row indicate amounts by which profit is decreased by a unit of activity.

One-litter systems. The litter each year is farrowed during the first part of May. On the average, 7.2 pigs are saved per litter. One gilt from each litter is saved for replacement. The remainder are marketed in November at the weight of 225 pounds. The cull sow from each litter is marketed in August at a weight of 350 pounds.

Two-litter systems. Litters are farrowed each year in February and August with an average of 7 pigs saved from the spring litter and 7.2 pigs saved from the fall litter. Gilt replacements are from the spring litters and the cull sows are sold in November at a weight of 400 pounds. Market hogs are sold in August and in January, at a weight of 225 pounds.

Four-litter systems. Litters are farrowed each year in February, May, August and November. The number of pigs saved per litter is, respectively, 7.0, 7.2, 7.2, and 7.0. Gilts are saved from the litters farrowed in February and May. Cull sows are sold in November and February at a weight of 400 pounds. Market hogs are sold in August, November, February, and May, at an average weight of 225 pounds.

Spring feeder-pigs. Spring feeder-pigs are purchased in April at a weight of 40 pounds, and sold in August at a weight of 225 pounds.

Table 13. — Budgets for Feeder-Pigs Bought on Non-Specialized Large Dairy Farms With 170 or More Crop Acres[a]

	Fattening feeder-pigs bought in		
	Spring	Fall (cash)	Fall (hog sales)
		(per head)	
Corn equivalent, bushels	12	12	12
Hours labor: Jan.-Mar.		1.28	1.28
Apr.-May	.64		
June-July	1.28		
August	.64		
Nov.-Dec.		1.28	1.28
Fattening capacity:			
Spring hogs, litter	.125		
Fall hogs, litter		.125	.125
Cash	15.51	15.51	
Non-real estate credit	−2.52	−2.52	
Revenue from spring hogs	−32.31		15.51
Hogs, hundredweight	−1.76	−1.46	−1.46
Profit	−7.26	−7.26	−7.26

[a] Negative signs denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column heads. The numbers in the last row indicate the amount by which profit is decreased by a unit of activity.

Fall feeder-pigs. Fall feeder-pigs are purchased in October at a weight of 40 pounds and sold in February at a weight of 225 pounds. Alternatives are provided to buy feeders with cash or with receipts from sale of hogs.

The similarity of budgets between pasture and confinement production systems may overstate the relative labor requirements for confinement production. On the other hand, data presently available are not conclusive on differences in labor requirements. The same is true of output per litter on pasture or in confinement.

An adjustment to allow for the seasonal price change of market hogs and sows was needed to put the quantities of hogs marketed at various times of the year on a comparable value basis. The average relation of market hog to cull sow prices for the period 1954-1958 was used to estimate a ratio between the value of a pound of cull sow and a pound of market hog. The Chicago price for 220-240-pound barrows and gilts, 330-360-pound sows, and 400-450-pound sows, were $18.99, $16.92, and $16.09 per hundredweight respectively.

These ratios then were used to adjust the weight of cull sows so that the adjusted weight would be equivalent to an identical weight of market hogs. Then the variation in market hog prices would also imply variation (in a fixed relation) of cull animals as well. As a result, a

Table 14. — Seasonal Price Variation for Hogs[a]

Month	Percent of average annual price	
	Barrows and gilts 220-240 pounds	All sows
January	94.0	90.8
February	96.8[b, c]	95.9[c]
March	97.9	97.9
April	100.4	99.1
May	103.6[c]	102.4[d]
June	107.3	104.5
July	110.0	106.0
August	110.0[b, c]	110.8[d]
September	104.0	109.5
October	95.7	102.1
November	89.9[c, d]	93.3[b, c]
December	90.3	87.6

[a] Source: Francis E. Walker, *Indexes of Prices of Illinois Farm Products,* University of Ilinois Department of Agricultural Economics, AE-3411 (mimeo), 1959.
[b] Used for two-litter systems and for purchased feeder-pigs.
[c] Used for four-litter systems.
[d] Used for one-litter systems.

350-pound sow was assumed equal in value to 255 pounds of barrows and gilts; a 400-pound sow, to 265 pounds of market hogs. Prices were further adjusted for seasonal variations according to indexes given in Table 14.

Borrowing capacity was increased at approximately 35 percent of the value of the pigs purchased. The value of the pig divided by value of pig plus value of feed required to fatten the pig is about 35 percent. This ratio is based on the assumption that the producer can borrow essentially 100 percent of the purchase price if he has enough feed to finish the market hog. The equivalent ratio for home-produced pigs is

Table 15. — Investment Alternatives in the Hog Enterprise, Non-Specialized Large Dairy Farms With 170 or More Crop Acres[a]

	Investment in hog capacity	
	Farrowing	Fattening
	(per litter)	
Farrowing capacity, litter	−2	
Fattening capacity:		
Spring hogs, litter		−2
Fall hogs, litter		−2
Real estate credit	372.47	301.95
Profit	−37.78	−29.48

[a] Negative signs denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column heads.

Table 16. — A Description of Beef Feeding Systems for Non-Specialized Large Dairy Farms With 170 or More Crop Acres[a]

Item	Choice steer calves			Good to choice yearling steers
	Long-fed drylot	Wintered and fed on pasture	Delayed feeding	Short-fed drylot
Number of droves	10	57	9	20
Date purchased	Oct. 13	Oct. 25	Oct. 5	Oct. 23
Date sold	Sept. 18	Oct. 25	Jan. 5	May 5
Total days on farm	340	365	457	194
Sale weight, pounds	1,008	1,077	1,136	1,064
Purchase weight, pounds[b]	440	440	440	700
Gain, pounds	568	637	696	364
Net gain per head per day, pounds	1.68	1.74	1.52	1.88
Feed fed per hundred pound gain				
Corn, bushels	8.2	7.8	8.1	9.7
Oats, other grain, bushels[c]	0.4	1.1	1.0	.5
Proteins and minerals, pounds	51	46	34	48
Hay, pounds	203	175	264	190
Silage,[d] corn, pounds	212	278	239	412
Grass and other, pounds	360	213	263	494
Pasture, animal unit days,[e] Fall	2.4	1.4	5.0	4.3
Spring	.5	5.9	7.3	...
Feeding program				
Days on fall pasture	38	24	58	26
Days wintered without silage	19[f]	45	46	...
Days silage fed	141	123	102	115
Days on spring pasture	4	102	136	...
Days full-fed grain on drylot	138	71	115	53
Total days on farm	340	365	457	194
Days on limited grain	128	157	193	63
Days on full feed	138	147	142	90
Percent death loss	1.1	1.8	3.1	.4

[a] Source: R. A. Hinton, "Feeds Fed Feeder-Cattle by System of Feeding," unpublished research, University of Illinois, Department of Agricultural Economics, Urbana, November, 1958, pp. 7, 10. All systems are with silage feeding.

[b] Purchase weights have been changed from those given by Hinton. Purchase weights in the original source were 453, 415, 424, 693 respectively.

[c] Oats and other grain were converted to corn equivalents at the rate of two bushels of oats and other grains per bushel of corn.

[d] One ton of corn silage equals 4.0 bushels of corn and 300 pounds of hay. One ton of grass silage equals 500 pounds of hay.

[e] Three and one-eighth animal unit days equals 100 pounds of hay.

[f] This figure was adjusted slightly from that given by Hinton so that the feeding program balanced with the number of days cattle were on the farm.

about 50 percent. Brood sows were allowed to create borrowing capacity to about 50 percent of their value.

To complete the hog alternatives, we present in Table 15 the investment alternatives permitted to expand the capacity to farrow and fatten hogs.

In addition to hogs and the dairy enterprise, a choice was provided among four systems of cattle feeding most common to the area. The

Table 17. — Budgets of Beef Feeding Systems for Non-Specialized Large Dairy Farms With 170 or More Crop Acres[a]

	Full-fed in drylot	Wintered and full-fed on pasture	Wintered and full-fed after pasture	Yearling steers short-fed
		(per head)		
Hay equivalent, tons	.92	.86	1.27	.68
Pasture, animal unit days	20	50	90	15
Corn equivalent, bushels	50	56.70	63.30	39.30
Hours labor: Jan.-Mar.	3.71	3.78	3.65	3.75
Apr.-May	2.01	2.13	2.01	1.24
June-July	1.80	1.84	1.56	
August	.92	.93	.86	
Sept.-Oct.	1.27	2.19	2.54	.38
Nov.-Dec.	1.62	1.26	2.99	2.00
Beef cattle fattening capacity, head	1	1	1	1
Cash	120.83	122.75	122.35	153.51
Non-real estate credit	−61.54	−58.84	−57.23	−126.37
Beef, hundredweight	−10.32	−10.99	−11.38	−10.55
Profit	−109.61	−110.54	−108.38	−143.82

[a] Negative signs denote additions to resources indicated in stub; positive numbers denote requirements per unit of activity indicated in column heads. Numbers in the last row indicate amounts by which profit is decreased by a unit of activity.

systems are described in Table 16 and summarized in budgets given in Table 17. Again, profit from each activity is shown as negative since returns are reflected in the value of sales from a beef resource supplied from each of these activities.

Additions can be made to cattle feeding capacity, drawing on real estate credit, at $67.20 per head of capacity added. Profit is reduced at $6.87 per head of capacity added. Finally, borrowing alternatives are provided for non-specialized dairy farms that are identical to those shown in Table 7 for specialized dairy farms.

Crop budgets for large non-specialized dairy farms with small crop acreages differ from those for large dairy farms with large crop acreages only in labor requirements. These are given in Table 18 for the small farms. Other items in the budgets of the different rotations are unchanged from Table 3. For small farms, as well as large farms, the alternative was provided to fertilize crops at rates that are average for the area. Yields, and hence contributions to feed supplies, are the same as those given in Table 9. Cash and profit rows also are the same as in Table 9. For harvesting, labor requirements are slightly higher on small farms as indicated in Table 19.

Labor requirements also differ slightly for the three milking alternatives differentiated in terms of grain : milk feeding ratios. For January through March, 18.49 hours are required per head of cows milked;

Table 18. — Labor Budgets of Crop Alternatives on Non-Specialized Large Dairy Farms With Less Than 170 Crop Acres[a]

		Corn-corn-oats	Corn-corn-oats-legume	Corn-soybeans-oats-legume	Corn-corn-soybeans-oats-legume	Corn-corn-oats-legume-legume
				(per acre)		
Hours labor:	Jan.-Mar.	.9	.7	.7	.6	.6
	Apr.-May	1.8	1.4	1.5	1.6	1.1
	June-July	1.8	1.4	1.2	1.2	1.1
	August	.3	.2	.1	.2	.2
	Sept.-Oct.			.5	.4	
	Nov.-Dec.			.3	.2	

[a] Each number represents hours of labor required, in the period indicated in stub, for one acre of rotation indicated in column head.

for April-May, 10.4; June-July, 8.41; August, 4.24; September-October, 8.41; and November-December, 12.16. Otherwise the budgets for milking alternatives are the same for the non-specialized large dairy farms with 170 or more crop acres and for the specialized dairy farms (see Table 5). To expand dairy capacity and silage capacity requires budgets identical to those shown in Table 7. For hog and beef feeding enterprises, the alternatives and budgets are the same for non-specialized dairy farms with small crop acreages as for large. Hence the relevant budgets are given in Tables 11 through 17.

For non-specialized farms with a cow capacity of less than 35 head, only those with less than 170 crop acres proved to be important as a source of milk. Feed supplies from crop rotations on these farms are the same as those given for non-specialized large dairy farms with 170

Table 19. — Labor Budgets of Harvest Alternatives for Crops on Non-Specialized Large Dairy Farms With Less Than 170 Crop Acres[a]

		Harvest 100 bushels of corn for		Harvest meadow for hay (10-ton equivalent)[b]
		Grain[b]	Silage[b]	
Hours labor:	Apr.-May			1.55
	June-July			20.15
	August			1.55
	Sept.-Oct.	3.05	17.4	7.75
	Nov.-Dec.	3.05		

[a] Each coefficient indicates labor required during the period indicated in stub, per unit of crop activity indicated in column head.
[b] Requirements other than these are the same as indicated in Table 4.

or more crops acres, and are given in Tables 8 and 9 for recommended and average fertility rates, respectively. Labor requirements are the same as those given in Table 18 for non-specialized large dairy farms with less than 170 crop acres. To harvest crops requires the same labor per unit on small dairy farms as on large dairy farms with less than 170 crop acres (see Table 19).

Milking alternatives were the same on small as on large dairy farms. However, labor requirements were slightly higher — equal to those of specialized dairy farms using the "traditional" milking system. The maximum intensity ration of 1:2 was excluded from the alternatives for small non-specialized dairy farms. To replace milk cows on small dairy farms required the same resources as for non-specialized large dairy farms (see page 16). Alternatives in hog production and beef feeding are the same on small as on large dairy farms, as is indicated by the budgets for these alternatives.

Table 20. — Projected Seasonal Average Prices Received by Farmers in 1965[a]

Item	Illinois price	U. S. price
Corn, bushels	$ 1.08	$ 1.10
Soybeans, bushels	2.04	2.00
Hay (all), tons	17.70	18.00
Alfalfa hay, tons	20.66	21.00
Hogs (all), hundredweight	14.50	14.50
Sows,[b] hundredweight	12.00	
Stags,[b] hundredweight	9.00	
Beef cattle (all), hundredweight	18.80	17.00
Fat steers (choice),[c] hundredweight	23.50	23.50
Veal calves, hundredweight	17.65	18.00
Cows (canners and cutters),[d] hundredweight	11.76	
Milk (Grade A-blend), hundredweight	(variably priced)	4.00
Eggs, dozen	.31	.37

[a] Prices are estimated from projected seasonal average U. S. prices received by farmers. Average U. S. prices are common prices given to all areas participating in the Lake States dairy adjustment study. The method of arriving at the projected prices for Illinois was identical to the method used by the U. S. Department of Agriculture, *Agricultural Price and Cost Projections for Use in Making Benefit and Cost Analyses of Land and Water Resource Projects and Analyzing the Repayment Capacity of Water Users,* Agricultural Research Service and Agricultural Marketing Service, Washington, September, 1957, p. 6. The percentage spread between the average U. S. price and the average Illinois price for the 1949-1958 period was applied to the projected U. S. price.

[b] These projected Illinois prices for sows and stags were estimated by E. E. Broadbent, Livestock Marketing Specialist, University of Illinois Department of Agricultural Economics. The estimates were based on a projected market hog price of $14.60 per hundredweight.

[c] The method described in footnote [(a)] was not used for fat steers because a comparable U. S. price and Illinois price does not exist for this type of cattle. The all-beef price differential is an unsatisfactory base for adjustment because the Illinois all-beef price is more heavily weighted by fat cattle and would cause an upward bias in the Illinois price of fat steers. Because of this, it was assumed that Illinois prices for fat cattle were identical to U. S. prices.

[d] Since no U. S. price was given, the following formula was used to derive an estimate:

$$\text{Illinois price of cows} = \frac{\text{1949-1958 average Chicago price of canners and cutters}}{\text{1949-1958 average U. S. price of all beef}} \$17.$$

This formula assumes that the estimated Chicago price of canners and cutters for 1965 will be the same proportion of the projected U. S. price of all-beef ($17.00) as it actually was from 1949-1958.

PRICES AND COST RATES

Estimates of 1965 price levels were used in the models. The estimates of prices received by Illinois farmers are presented in Table 20, and prices paid by farmers are presented in Table 21. Building costs for various types of livestock facilities are presented in Table 22.

Table 21. — Projected Estimates of Prices Paid by Farmers in 1965

Item	Illinois price
Fertilizer[a]	
Nitrogen (N)	$ .12 per pound
Phosphate (P_2O_5)	.08 per pound
Potassium (K_2O)	.04 per pound
Feeds	
Corn	1.16 per bushel
Hay (alfalfa-bromegrass)	28.66 per ton
Soybean meal (44%)[b]	4.25 per hundredweight
Salt[b]	2.00 per hundredweight
Bonemeal[b]	5.75 per hundredweight
Laying mash[b]	5.15 per hundredweight
Starter and grower[c]	4.70 per hundredweight
Minerals, vitamins and antibiotics for hog ration[d]	3.75 per ton of feed
Livestock	
Breeding fee (Holstein service)[e]	7.00 per head
8,700-pound cow[f]	280.00 per head
10,000-pound cow[f]	320.00 per head
11,500-pound cow[f]	370.00 per head
Sow[g]	60.00 per head
Boar[g]	75.00 per head
Choice feeder calves (Under 500 lb.)[h]	22.50 per hundredweight
Choice feeder steers (500-800 lb.)[h]	20.50 per hundredweight

[a] Fertilizer price assumptions were based on a random sample of fertilizer dealers in Champaign County in 1958, taken by Max F. Jordan, Department of Agricultural Economics, University of Illinois. A charge of $1.00 per rotation acre per year was made for limestone maintenance.

[b] These feed prices are based on averages of price quotations from selected feed firms in Champaign County.

[c] The average price of starter and grower is based on a weighted average of prices of starter and of grower mash from local dealers. The starter-grower ration was assumed to be 1 part starter and 8 parts grower. One assumes that a chick is fed starter until 8 weeks of age and grower until 24 weeks of age. L. E. Card, *Practical Poultry Feeding*, Ill. Ext. Cir. 606, Urbana, January 1956, p. 4, presents data that suggest these proportions.

[d] Prices suggested by D. E. Becker, Department of Animal Science, University of Illinois. Prices are for a ration made up of 1 part Illinois ration 16, and 1 part Illinois ration 12, (D. E. Becker, *Balancing Swine Rations*, Ill. Ext. Cir. 811, Urbana, December 1959).

[e] This assumption was based on the 1960 charge made by cooperative breeding associations in Illinois.

[f] Cow prices were estimated by obtaining the average historic value of a cow per 100 pounds of milk produced and multiplying this figure by the hundredweights of milk produced by a cow whose value was being estimated. For example, for a 8,700-pound cow:

$$\frac{\$200.00}{62.16} = \$3.22 \ (8{,}700) = \$280.14 \text{ rounded to } \$280.00 \text{ (the nearest } \$10.00)$$

where $200 is the average price Illinois farmers received for milk cows from 1949-1958, and 62.16 is the average number of hundredweights of milk produced by Illinois cows from 1949-1958. Leo R. Fryman, University of Illinois, Department of Dairy Science, verified the price assumptions as being good estimates of 1959 cow prices.

[g] R. A. Hinton, *Farm Management Manual*, University of Illinois, Department of Agricultural Economics, (mimeo) AE-3349, Urbana, May 1959, p. 9.

[h] Prices assumed to be the same as the U. S. prices given for the Lake States dairy study.

Table 22. — Building Costs Assumed for Northeastern Illinois in 1965[a]

Item	Total cost	Annual cost
Silo, 130-ton capacity	$1,900.00	$163.65
Loafing space per cow[b]	238.93	25.08
Farrowing facility, for 2 sows	372.47	37.78
Hog fattening facility, 2-litter	301.95	29.48
Beef fattening facility, per head	67.20	6.87

[a] Annual costs include depreciations, interest on average undepreciated value, insurance, and taxes.

[b] The building costs given here are those assumed to be associated with the expansion of a stanchion system. Since it is assumed that the present stanchion system will serve as a milking barn, and that a shift system of milking will be used, the costs given here include only loafing space and hay storage.

THE RESULTS

With these models, plans were obtained that indicate the amount of milk the average farm in each class would produce at each of the varied prices of milk, and, in selected farm situations, at varied prices of hogs, beef cattle, corn, and labor. To use estimates thus obtained as predictions of milk attracted by actual milk prices requires an assumption that all producers would use resources so as to maximize profits. It is reasonable to expect that producers prefer more to less income, though other motivations also are doubtless important. Actual market supplies at comparable prices do not differ greatly from our supply estimates in the range of blend prices for milk since 1950.

Specialized dairy farms

In Table 23 we report milk production and the value of a dairy cow added to the herd for 84 situations differentiated in terms of: milk price (7 prices from $2.70 to $5.10 per hundredweight); corn price (3 prices from 97 cents to $1.19 per bushel); and labor situation (none hired or, alternatively, hired at $2.08, $1.56, or $1.04 per hour). All results relate to farms with livestock facilities for dairy only. At any given price of corn and any given labor situation, response to increasing price of milk is an increase in size of herd, and intensification of the grain : milk feeding ratio, a change to more corn-intensive ration, and a change to buying instead of raising replacements. Capacity can be added beyond 36 cows and 227 tons of silage.

Results in Table 23 suggest that milk production responds but little to the opportunity to hire labor until milk is priced at nearly $4.00 per hundredweight. Indeed there is no response at milk prices of less than $3.50. Some response is observed at $3.90 for milk. This tends to strengthen at $4.30 and $4.70, and to increase more the lower the wage

Table 23. — Milk Production per Year and Value of Added Cow at Selected Prices of Milk and Corn (Sold) and at Labor Fixed and Labor Hired at Selected Wage Rates, Specialized Dairy Farms, Northeastern Illinois

Price of milk	Price of corn	Milk produced per year				Marginal value product of milk cow			
		No labor hired	Labor hired at (per hour)			No labor hired	Labor hired at (per hour)		
			$2.08	$1.56	$1.04		$2.08	$1.56	$1.04
(hundredweight)	(bushel)	(hundredweight)				(dollars)			
$2.70	$ .97	1,860	1,860	1,860	1,860	104	104	104	104
	1.08	1,860	1,860	1,860	1,860	104	104	104	104
	1.19	927	927	927	927	103	103	103	103
3.10	.97	2,310	2,310	2,310	2,310	124	124	124	124
	1.08	1,860	1,860	1,860	1,860	123	123	123	123
	1.19	927	927	927	927	122	122	122	122
3.50	.97	2,379	2,379	2,423	2,423	144	144	143	143
	1.08	2,379	2,379	2,379	2,379	143	143	143	143
	1.19	2,310	2,310	2,310	2,310	142	142	142	142
3.90	.97	2,379	2,423	2,700	2,700	161	159	159	159
	1.08	2,379	2,423	2,423	2,700	160	159	159	159
	1.19	2,379	2,423	2,423	2,700	160	159	159	159
4.30	.97	2,379	2,700	2,864	3,341	179	176	175	178
	1.08	2,379	2,700	2,700	3,341	178	175	175	176
	1.19	2,379	2,700	2,700	2,864	177	175	175	176
4.70	.97	2,433	2,864	3,341	3,341	195	192	194	199
	1.08	2,392	2,700	3,341	3,341	196	192	192	197
	1.19	2,379	2,700	2,864	3,341	194	192	191	194
5.10	.97	2,433	3,341	3,341	3,490	209	210	215	221
	1.08	2,433	3,341	3,341	3,341	211	208	213	218
	1.19	2,393	2,864	3,341	3,341	211	207	211	216

rate. At $5.10, the response to lowering wage rates is slight. Response to variation in the price of corn is the same for all four labor situations when milk is priced at $3.50 or less. Some decrease in milk production can be noted in relation to increased corn prices at $3.90 or more for milk. The decrease is more marked with labor hired than when no labor is hired and tends to increase as wage rates decline. In the most relevant range of milk prices, $3.90-$4.70, milk production is more responsive to wage rates than to corn price. One must, however, recognize that wages were varied over a wider range than was corn price.

In the last four columns of Table 23 we report the value of a cow added to the herd at each of the price combinations. Cow value is in-

creased by an increase in milk price and is usually decreased by an increase in wage rate or corn price. When no labor is hired, 40-cent increments in milk price increase cow value by about $20 per head at milk prices of $2.70-3.50, the increases declining to about $15 per head at $4.30-5.10. When labor can be hired, increases in cow values hold more steadily over the range of milk prices. We note that at the more relevant price combinations the value of a cow added to the herd appears low in relation to the cost of replacements in the Chicago area. This suggests that dairying is a relatively unattractive alternative in the area. On these specialized farms, however, there is little other use for resources.

In Table 24 we report the use of the 188 acres of cropland consistent with profit maximization at each of the price combinations, under each labor situation. For corn priced at 97 cents and $1.08, 75 acres are planted to corn. At $1.19, 125 acres are planted to corn when milk is priced at less than $3.50. When no labor is hired, 80 acres in corn is optimal at from $4.30 to $5.10 for milk. Otherwise 75 acres is optimal. Soybeans are driven from optimum plans with corn at $1.19 when milk is less than $3.50. At $3.50 and $3.90 soybeans reappear, varying from 19 to 31 acres, the acreage tending to decrease with decrease in wage rates and increase in milk price. When milk is more than $4.30, soybeans drop from optimum plans at $1.04 per hour for labor. They remain at $4.30 for milk when corn sells for $1.19. At $4.70, soybeans are dropped at $1.56 for labor, except when corn is $1.19. At $5.10 for milk, soybeans are dropped at $2.08 for labor, except when corn is $1.19. Thus while corn and soybeans appear competitive at low milk prices, they are somewhat complementary at high prices.

Oats are included in all four rotation alternatives and meadow in three of the four. Oats in optimum plans are at the minimum of 38 acres except at $1.19 for corn, with milk priced at $3.10 or less per hundredweight. Another minor exception occurs, with no hired labor, at $1.19 for corn when milk reaches $4.30 or more. Acreage in meadow increases with increases in the price of milk and with decreases in wage rates. Meadow is driven from optimum plans by $1.19 corn when milk is priced at $3.10 or less per hundredweight.

Further insight into the effect of varying prices can be obtained from a review of Table 25. In the first four columns we show the amount by which profit would be increased by adding another acre of cropland at each of the indicated price combinations. We define such an increase to be the "marginal value" of cropland. Clearly the marginal value of cropland increases when there are increases in the price

Table 24. — Acres of Corn, Soybeans, Oats and Meadow in Optimum Plans at Selected Prices of Milk and Corn, Under Specified Labor Situations, Specialized Dairy Farms, Northeastern Illinois

Price of milk	Price of corn	No labor hired		Labor hired at					
				$2.08 per hour		$1.56 per hour		$1.04 per hour	
		Corn, soybeans	Oats, meadow	Corn, soybeans	Oats, meadow	Corn, soybeans	Oats, meadow	Corn, soybeans	Oats, meadow
		(acres)				(acres)			
$2.70	$ .97	75, 37	38, 38	75, 37	38, 38	75, 37	38, 38	75, 37	38, 38
	1.08	75, 37	38, 38	75, 37	38, 38	75, 37	38, 38	75, 37	38, 38
	1.19	125, 0	63, 0	125, 0	63, 0	125, 0	63, 0	125, 0	63, 0
3.10	.97	75, 31	38, 44	75, 31	38, 44	75, 31	38, 44	75, 31	38, 44
	1.08	75, 37	38, 38	75, 37	38, 38	75, 37	38, 38	75, 37	38, 38
	1.19	125, 0	63, 0	125, 0	63, 0	125, 0	63, 0	125, 0	63, 0
3.50	.97	75, 29	38, 46	75, 29	38, 46	75, 28	38, 47	75, 28	38, 47
	1.08	75, 29	38, 46	75, 29	38, 46	75, 29	38, 46	75, 29	38, 46
	1.19	75, 31	38, 44	75, 31	38, 44	75, 31	38, 44	75, 31	38, 44
3.90	.97	75, 29	38, 46	75, 28	38, 47	75, 19	38, 56	75, 19	38, 56
	1.08	75, 29	38, 46	75, 28	38, 47	75, 28	38, 47	75, 19	38, 56
	1.19	75, 29	38, 46	75, 28	38, 47	75, 28	38, 47	75, 19	38, 56
4.30	.97	75, 29	38, 46	75, 19	38, 56	75, 14	38, 61	75, 0	38, 75
	1.08	75, 29	38, 46	75, 19	38, 56	75, 19	38, 56	75, 0	38, 75
	1.19	80, 22	40, 46	75, 19	38, 56	75, 19	38, 56	75, 14	38, 61
4.70	.97	75, 29	38, 46	75, 14	38, 61	75, 0	38, 75	75, 0	38, 75
	1.08	75, 29	38, 46	75, 19	38, 56	75, 0	38, 75	75, 0	38, 75
	1.19	80, 22	40, 46	75, 19	38, 56	75, 14	38, 61	75, 0	38, 75
5.10	.97	75, 29	38, 46	75, 0	38, 75	75, 0	38, 75	75, 0	38, 75
	1.08	75, 29	38, 46	75, 0	38, 75	75, 0	38, 75	75, 0	38, 75
	1.19	81, 21	40, 46	75, 14	38, 61	75, 0	38, 75	75, 0	38, 75

Table 25. — Value of an Added Acre of Cropland or an Added Ton of Hay at Selected Prices of Corn (Sold), and at Labor Fixed and Labor Hired at Selected Wage Rates, Specialized Dairy Farms, Northeastern Illinois

Price of milk	Price of corn	Marginal value product of cropland				Marginal value product of hay			
		No labor hired	Labor hired per hour at			No labor hired	Labor hired per hour at		
			$2.08	$1.56	$1.04		$2.08	$1.56	$1.04
					(dollars)				
	$ .97.....	24.02	24.02	24.02	22.72	22.72	22.72	22.72	22.72
$2.70	1.08.....	27.23	27.23	27.23	21.28	21.28	21.28	21.28	21.28
	1.19.....	33.41	33.41	33.41	33.41	19.85	19.85	19.85	19.85
	.97.....	26.89	26.89	26.89	26.89	26.82	26.82	26.82	26.82
3.10	1.08.....	30.01	30.01	30.01	30.01	25.26	25.26	25.26	25.26
	1.19.....	34.20	34.20	34.20	34.20	23.82	23.82	23.82	23.82
	.97.....	23.78	23.78	23.85	24.09	26.93	26.93	26.87	26.66
3.50	1.08.....	29.68	29.68	29.68	29.68	26.87	26.87	26.87	26.87
	1.19.....	35.32	35.32	35.32	35.32	26.82	26.82	26.82	26.82
	.97.....	19.48	20.40	21.60	22.96	27.07	26.28	26.38	26.53
3.90	1.08.....	25.38	25.87	26.11	27.45	27.01	26.59	26.38	26.53
	1.19.....	31.27	31.33	31.58	31.94	26.96	26.90	26.70	26.53
	.97.....	15.19	19.53	20.37	24.52	27.21	26.23	26.19	28.83
4.30	1.08.....	21.08	24.02	25.38	26.48	27.15	26.23	26.38	27.06
	1.19.....	26.98	28.52	29.87	29.94	27.09	26.23	26.38	26.07
	.97.....	11.72	17.44	21.25	30.30	26.64	25.74	28.20	33.34
4.70	1.08.....	16.78	23.31	23.20	32.25	27.30	26.23	26.43	31.57
	1.19.....	23.02	27.80	27.01	34.21	26.94	26.23	25.62	29.81
	.97.....	8.77	17.98	27.02	36.10	25.63	27.57	32.71	37.87
5.10	1.08.....	13.43	19.93	28.98	38.02	26.63	25.80	30.94	36.08
	1.19.....	19.08	24.08	30.93	39.98	26.78	25.16	29.18	34.32

of corn, regardless of milk prices or labor conditions. However, the marginal value of cropland is little related to wage rates at milk prices of $3.90 or less, and decreases as milk prices increase beyond $3.10 per hundredweight.

The value of an increment of hay is also of interest. In the model, hay is supplied only from harvesting, as opposed to grazing, meadow. And the acreage in meadow varies according to the selection made among the four crop rotations. Use of hay varies according to ration selected as well as system of feeding for dairy cows. One would expect, in general, that the marginal value product (MVP) of hay would decline with respect to increases in the price of corn; increase with respect to the price of milk until it is high enough to justify a ration and sys-

Table 26. — Number of Cows Fed Traditionally at Grain:Milk Ratios of 1:2; 1:2.5; and 1:4; at Selected Prices of Milk and Corn and at Labor Fixed and Labor Hired at Selected Wage Rates, Specialized Dairy Farms, Northeastern Illinois

Price of milk	Price of corn	No labor hired	Labor hired at		
			$2.08 per hour	$1.56 per hour	$1.04 per hour
		Number of cows fed (and grain:milk ratios)			
	$ .97.....	19 (1:4)	19 (1:4)	19 (1:4)	19 (1:4)
$2.70	1.08.....	19 (1:4)	19 (1:4)	19 (1:4)	19 (1:4)
	1.19.....	9 (1:4)	9 (1:4)	9 (1:4)	9 (1:4)
	.97.....	21 (1:2.5)	21 (1:2.5)	21 (1:2.5)	21 (1:2.5)
3.10	1.08.....	19 (1:4)	19 (1:4)	19 (1:4)	19 (1:4)
	1.19.....	9 (1:4)	9 (1:4)	9 (1:4)	9 (1:4)
	.97.....	22 (1:2.5)	22 (1:2.5)	22 (1:2.5)	22 (1:2.5)
3.50	1.08.....	22 (1:2.5)	22 (1:2.5)	22 (1:2.5)	22 (1:2.5)
	1.19.....	22 (1:2.5)	21 (1:2.5)	21 (1:2.5)	21 (1:2.5)
	.97.....	22 (1:2.5)	22 (1:2.5)	25 (1:2.5)	25 (1:2.5)
3.90	1.08.....	22 (1:2.5)	22 (1:2.5)	22 (1:2.5)	25 (1:2.5)
	1.19.....	22 (1:2.5)	22 (1:2.5)	22 (1:2.5)	25 (1:2.5)
	.97.....	22 (1:2.5)	25 (1:2.5)	26 (1:2.5)	31 (1:2.5)
4.30	1.08.....	22 (1:2.5)	25 (1:2.5)	25 (1:2.5)	31 (1:2.5)
	1.19.....	22 (1:2.5)	25 (1:2.5)	25 (1:2.5)	26 (1:2.5)
	.97.....	10 (1:2); 12 (1:2.5)	26 (1:2.5)	31 (1:2.5)	31 (1:2.5)
4.70	1.08.....	22 (1:2.5)	25 (1:2.5)	31 (1:2.5)	31 (1:2.5)
	1.19.....	22 (1:2.5)	25 (1:2.5)	26 (1:2.5)	31 (1:2.5)
	.97.....	10 (1:2); 12 (1:2.5)	31 (1:2.5)	31 (1:2.5)	31 (1:2)
5.10	1.08.....	10 (1:2); 12 (1:2.5)	31 (1:2.5)	31 (1:2.5)	31 (1:2.5)
	1.19.....	22 (1:2.5)	26 (1:2.5)	31 (1:2.5)	31 (1:2.5)

tem emphasizing more corn; and increase with lowered wage rates. These relations seem to hold in Table 25. The marginal value product of hay varies little with respect to corn price, however, or to wage rates at milk prices around $3.90.

In all solutions, the traditional feeding system was found consistent with profit-maximizing plans. (See Table 26.) Within this system the grain:milk ratio of 1:2.5 dominates at milk prices of $3.50 and higher. At $4.70 and $5.10 the 1:2 ratio appears; below $3.50, 1:4. Change in the price of corn had little effect on choice of ration except in these extremes of milk price. Only at high milk prices did wage rates exert any influence. At $5.10 there appeared some tendency to intensify the ration at lower wage rates.

Non-specialized dairy farms

For non-specialized dairy farms, milk supply was estimated in response to varied hog prices as well as milk prices.[1] Results for large dairy farms are reported in Table 27. On farms with 170 or more crop acres no milk was produced in optimum farm plans with the price of milk at less than $3.90 per hundredweight. Indeed, no hogs were produced either, cattle being fed with corn from corn-intensive crop rotations, supplemented with the purchase of nearly 7,500 bushels. The limiting resource was capital, all possible credit being used to finance crop production and cattle feeding.

At $14.60 per hundredweight or less for hogs, milk production becomes profitable when the price of milk is $3.90 per hundredweight or more. Milk production response is the same at $11.60 and $13.10 for hogs, and differs only slightly at $14.60 for hogs, although an interesting complementarity between hog and milk production appears at the latter price and $4.30 per hundredweight for milk. At $4.30 for milk dairy animals replace some cattle fed in the optimum plan as the hog price increases from $13.10 to $14.60.

For farms with less than 170 crop acres, the pattern of response is the same. Complementarity between milk and hog production is more pronounced. We note a positive response in milk production to increased hog prices from $11.60 to $13.10, at $4.70 per hundredweight for milk, and to increased hog prices from $14.60 to $16.10 at $4.30 per hundredweight for milk. In each case, cattle feeding appears to link hog to milk production, cattle numbers giving way to cow numbers as hogs increase in response to higher hog prices. The crop rotation becomes more corn-intensive, with more corn harvested as silage. Labor becomes a limiting resource in January-March, June-July, and September-October.

At low milk prices, investments are made in added facilities for cattle feeding. At higher prices, investments are made in added facilities for hogs. Dairy facilities are not added to those already on the farm until milk is priced at $4.70 per hundredweight or more. Silo capacity is added on the large crop farms when hogs are $17.60 or more, with milk priced at $4.30 per hundredweight or less. On the small crop farms, silo capacity is added at a milk price of $3.90 or less when hogs

[1] For details of optimum plans for non-specialized dairy farms, see Max R. Langham and C. B. Baker, *Optimum Plans for Farms in Northeastern Illinois: A Statistical Summary,* University of Illinois, Department of Agricultural Economics, AERR-40, December 1960.

Table 27. — Milk, Hogs, and Beef Cattle Produced in Profit-Maximizing Plans on Non-Specialized Dairy Farms With Capacity for 35 or More Dairy Cows, at Selected Prices of Milk and Hogs, Given $23.50 as Price of Fed Steers

Price of hogs	Units produced	Price of milk (dollars per hundredweight)				
		2.70-3.50	3.90	4.30	4.70	5.10
(hundredweight)						
	A. Production on 170 or more crop acres					
	Milk, cwt.	0	1,516	2,349	5,564	7,281
$11.60	Hogs, head	0	0	0	0	0
	Cattle, head	359	320	292	136	53
	Milk, cwt.	0	1,516	2,349	5,635	7,281
13.10	Hogs, head	0	0	0	77	63
	Cattle, head	359	320	292	130	53
	Milk, cwt.	0	1,516	3,386	5,635	7,281
14.60	Hogs, head	0	0	79	77	63
	Cattle, head	359	320	241	130	53
	Milk, cwt.	0	0	3,386	5,635	7,281
16.10	Hogs, head	128	128	79	77	85
	Cattle, head	334	334	241	130	54
	Milk, cwt.	0	0	0	5,564	6,547
17.60	Hogs, head	1,170	1,170	1,170	206	159
	Cattle, head	196	196	196	109	77
	Milk, cwt.	0	0	0	0	6,137
19.10	Hogs, head	1,537	1,537	1,537	1,537	225
	Cattle, head	114	114	114	114	80
	B. Production on less than 170 crop acres					
	Milk, cwt.	0	0	3,743	4,037	4,674
$11.60	Hogs, head	0	0	0	0	0
	Cattle, head	0	219	63	49	20
	Milk, cwt.	0	0	3,743	4,590	4,674
13.10	Hogs, head	0	0	0	88	88
	Cattle, head	0	219	63	24	20
	Milk, cwt.	0	0	3,743	4,661	5,093
14.60	Hogs, head	0	0	166	192	204
	Cattle, head	0	219	63	20	0
	Milk, cwt.	0	325	4,037	4,620	5,090
16.10	Hogs, head	88	88	203	219	205
	Cattle, head	202	193	47	20	0
	Milk, cwt.	0	0	0	4,620	5,112
17.60	Hogs, head	1,094	1,094	1,094	219	237
	Cattle, head	59	59	59	20	0
	Milk, cwt.	0	0	0	0	5,112
19.10	Hogs, head	1,214	1,214	1,214	1,214	237
	Cattle, head	37	37	37	37	0

Table 28. — Milk, Hogs, and Beef Cattle Produced in Profit-Maximizing Plans on Small Non-Specialized Dairy Farms With Capacity for Less Than 35 Dairy Cows, at Selected Prices of Milk and Hogs, Given $23.50 as the Price of Fed Steers

Price of hogs	Units Produced	Price of milk (dollars per hundredweight)				
		2.70-3.50	3.90	4.30	4.70	5.10
$11.60	Milk, cwt.	0	635	1,015	2,647	3,412
	Hogs, head	0	0	0	0	0
	Cattle, head	161	145	135	56	20
13.10	Milk, cwt.	0	635	1,015	3,132	3,423
	Hogs, head	0	0	0	88	84
	Cattle, head	161	145	135	32	19
14.60	Milk, cwt.	0	635	2,222	3,323	3,505
	Hogs, head	0	0	88	130	141
	Cattle, head	161	145	77	23	14
16.10	Milk, cwt.	0	1,227	2,618	3,360	3,630
	Hogs, head	88	88	113	143	158
	Cattle, head	144	113	56	20	9
17.60	Milk, cwt.	0	0	0	3,360	3,630
	Hogs, head	786	786	786	143	158
	Cattle, head	48	48	48	20	9
19.10	Milk, cwt.	0	0	0	0	3,564
	Hogs, head	957	957	957	957	179
	Cattle, head	20	20	20	20	7

are priced at $11.60, and with milk priced at $4.30 and $4.70, when hogs are priced at $16.10 or more.

On non-specialized small dairy farms, milk also must be priced at $3.90 or more per hundredweight to be competitive in profit-maximizing plans (see Table 28). Production is higher at higher milk prices and also at higher hog prices, until hogs are priced at $17.60 or more per hundredweight. Similarly, hogs respond positively to increased hog prices of $13.10 or more, and to increases in the price of milk between $4.30 and $5.10, with hogs priced at between $13.10 and $16.10. Again, the linkage appears to be in the cattle feeding enterprise, cattle numbers declining as hog and dairy cow numbers increase. Labor becomes more fully used at higher prices for milk and for hogs, and even becomes a limiting factor. Changes in crop rotations and additions to capacity for cattle, dairy, hogs, and silage parallel in a general way the changes observed for the larger farms already discussed.

Variants

For large non-specialized dairy farms with 170 or more crop acres, three variants were analyzed. In the first, the price of fed cattle was

varied to obtain changes that would be optimum in milk production and farm organization. In the second, it was assumed that the quality of cows were, alternatively, lower and higher than the quality assumed above. In the third, labor was allowed to be hired, if profitable, at a wage rate of $1.04 per hour. Specifically, in the first variant the price of beef cattle was varied from the price of $23.50 per hundredweight (used in all preceding analyses) to $21.50, $25.50, and $27.50 per hundredweight for fed cattle. The price of feeders was varied to retain a margin below the price of fed cattle. The quality of dairy cows was so varied that at a grain:milk feed ratio of 1:4 (hay fed free choice), a cow was assumed to produce 8,700 or 11,500 pounds of 3.5-percent fat-corrected milk per year, compared with the 10,000 pounds assumed in all preceding analyses.

Results from the first variant are summarized in Table 29. Milk production response to increased milk price varies little among the three different hog prices at either price for fed beef cattle. However, the response is substantially higher at all hog prices when cattle are $21.50 than when they are $25.50. Milk quantities reported in Table 29 equal or exceed those in Table 27 (farms with 170 or more acres) at all comparable prices for milk and hogs, when cattle are priced at $21.50. When cattle are $25.50, milk quantities are equal or less than those in Table 26 for all comparable prices of milk and hogs. Thus while hogs tend to complement milk production in the use of resources, the evidence suggests that beef cattle feeding and dairy production are competitive.

At $13.10 for hogs, hogs are produced with milk prices of $4.30 or more as long as beef cattle are priced no higher than $21.50. An exception is noted with beef cattle at $25.50 and milk at $5.10 per hundredweight. At $14.60 for hogs, hogs are produced at all milk prices when beef is $21.50, and also when beef is $25.50, for milk prices of $4.70 and $5.10. At $16.10 for hogs, the same general pattern is observed as when beef is $21.50 per hundredweight, though the level of hog production tends to be higher. At $25.50 for beef cattle, hogs are in the optimum plan at milk prices of $4.30 or higher. With cattle at $27.50, no hogs are produced except at $16.10 for hogs and $5.10 for milk. Long-fed steer calves dominate feeding systems in the optimum plans, the only exception being short-fed yearlings when cattle are $21.50, hogs $16.10, and milk between $2.70 and $3.50 per hundredweight.

Results from the second and third variants are combined in Table 30, and compared with milk produced in the basic plan for non-special-

Table 29. — Milk, Hogs and Beef Cattle in Profit-Maximizing Plans on Non-Specialized Large Dairy Farms With 170 or More Crop Acres, at Selected Prices of Milk, Hogs, and Fed Cattle

Price of hogs	Units produced	Price of milk, $2.70–3.50			Price of milk, $3.90			Price of milk, $4.30			Price of milk, $4.70			Price of milk, $5.10		
		Price of fed cattle			Price of fed cattle			Price of fed cattle			Price of fed cattle			Price of fed cattle		
		$21.50	25.50	27.50	$21.50	25.50	27.50	$21.50	25.50	27.50	$21.50	25.50	27.50	$21.50	25.50	27.50
	Milk, cwt.	0	0	0	5,193	0	0	5,635	2,143	0	7,281	2,349	2,365	7,281	5,564	2,365
$13.10	Hogs, head	0	0	0	0	0	0	77	0	0	63	0	0	63	64	0
	Cattle, head	364	354	350	152	354	350	130	300	350	53	292	291	53	134	291
	Milk, cwt.	0	0	0	5,564	0	0	5,635	2,143	0	7,218	2,612	2,365	7,281	5,564	2,365
14.60	Hogs, head	128	0	0	77	0	0	77	0	0	85	49	0	63	77	0
	Cattle, head	339	354	350	134	354	350	130	300	350	54	279	291	53	134	291
	Milk, cwt.	0	0	0	5,396	0	0	5,564	2,349	0	7,218	2,612	2,365	7,218	5,564	2,808
16.10	Hogs, head	1,122	0	0	195	0	0	185	16	0	85	49	0	85	77	56
	Cattle, head	307	354	350	118	354	350	112	292	350	54	279	291	54	134	269

Table 30. — Milk Produced in Profit-Maximizing Plans on Non-Specialized Large Dairy Farms With Large Crop Acreage, at Selected Prices of Milk, Alternate Assumptions on Quality of Dairy Cows and Labor Hiring

Price of milk	Quality of dairy cows			
	Low[a]	Medium[b]		High[c]
	Family labor only	Family labor only[d]	Family plus hired labor[e]	Family labor only
	(hundredweight)			
$2.70-3.50	0	0	0	0
3.90	0	1,516	1,516	2,666
4.30	1,291	3,386	5,564	6,355
4.70	3,049	5,635	12,097	7,498
5.10	4,733	7,281	12,828	8,245

[a] Cow produces 8,700 pounds per year of 3.5-percent fat-corrected milk, when fed at a grain : milk ratio of 1:4 with hay fed free choice.
[b] Cow produces 10,000 pounds per year of 3.5-percent fat-corrected milk, when fed at a grain : milk ratio of 1:4 with hay fed free choice.
[c] Cow produces 11,500 pounds per year of 3.5-percent fat-corrected milk, when fed at a grain : milk ratio of 1:4 with hay fed free choice.
[d] From Table 27, Part A, hogs priced at $14.60 per hundredweight.
[e] Labor is hired at $1.04 per hour.

ized large dairy farms of large crop acreage (column 3). Compared with the basic plan, cows of lower quality raise the minimum price required to make milk production profitable and reduce the response to increases in milk price. Higher quality cows have the opposite effect. Reduction in cow quality eliminates hogs from the profit-maximizing plans for milk prices less than $4.70 per hundredweight. However, at prices of $4.70 and $5.10, the number of hogs fattened exceeds slightly the number fattened in the basic plan. Increased cow quality had little effect on the response of hog production to the price of milk. With cows of low quality, the number of cattle fed increases substantially over the number shown in the basic plan. High-quality cows yielded the opposite results except at the extreme milk price of $5.10, when the number of cattle fed fell in most cases.

Summary comments on the farm plans

Hog and dairy enterprises together tend to compete with feeder-cattle in the profit-maximizing plans, at prices for hogs and milk of $16.10 and $4.70 per hundredweight or less, respectively. At higher prices, dairy and hogs compete, primarily for the use of labor. When labor was allowed by specification to be hired, milk production responded substantially. (See Table 30.)

The fattening of spring and fall feeder-pigs (financed with revenue from the sale of fattened spring feeder-pigs) were the most common types of hog enterprises among the profit-maximizing plans. The 2-litter pasture system was common among the plans. Neither 1-litter systems nor confinement farrowing and fattening appeared in any of the profit-maximizing plans. The profitability of fattening purchased feeder-pigs raises a question on the source of feeder-pigs and their quality. However, the results may be taken to indicate the strong possibility of profit from raising feeder-pigs in other areas, perhaps in other parts of Illinois as well as parts of Wisconsin, to be shipped into this and other areas of Illinois with special advantages in fattening hogs.

The most common types of cattle feeding were steer calves long-fed in drylot; steer calves full-fed on pasture after wintering on limited grain; and yearlings, short-fed in drylot. Cattle were fed in all profit-maximizing plans and were dominant at low prices for milk and hogs. This result accords well with the high incidence of cattle feeding found in the study area.

All plans used whatever cash was available. In addition, short-term credit was often exhausted when cattle were dominant in the plans. However, a surplus of credit resulted from plans in which hogs or dairy enterprises were dominant. Long-term credit was used in every plan, but was not limiting in any. Its use was greatest when dairy expansion required expansion of dairy and silage capacity.

The combination of dairy and hog enterprises is common among actual farm organizations in the area, as well as in the optimum plans generated by the linear programming models. However, it is not common to find cattle feeding combined with dairy and hog production. Many farmers are unable or unwilling to manage the three in one organization. In constructing the models, moreover, it is difficult to introduce effects of uncertainties associated with cattle feeding in such a way as to make the enterprise comparable with dairying. Finally, the difference between actual and optimal organizations is not large at price combinations for hogs, cattle, and milk that are historically common in the area.

Area supply relations

Aggregative results are given in Table 31. They are confined to the quantities inferred for specialized dairy farms, non-specialized large dairy farms with both large and small acreages, and small dairy farms, these being the important sources of milk in optimum plans. The method used to aggregate milk quantities assumes no interfarm interaction arising from the demand for inputs which would affect the price

Table 31. — Milk per Year From the Illinois Section of Chicago Supply Area (Thousands of Pounds per Year), by Source

Price of hogs	Price of milk	Specialized dairy	Non-specialized dairy farms			All strata
			Large dairy[a]		Small dairy[b]	
			Large crop acreage[c]	Small crop acreage[d]	Small crop acreage[d]	
Number of farms[e]		1,634	779	315	472	3,200
			(thousands of pounds per year)			
$11.60	$3.10	303,924				303,924
	3.50	388,729				388,729
	3.90	388,729	118,096		29,972	536,797
	4.30	388,729	182,987	117,905	47,908	737,529
	4.70	388,729	433,514	127,166	124,938	1,074,347
	5.10	397,552	567,190	147,231	161,046	1,273,019
13.10	3.10	303,924				303,924
	3.50	388,729				388,729
	3.90	388,729	118,096		29,972	536,797
	4.30	388,729	182,987	117,905	47,908	737,529
	4.70	388,729	438,967	144,585	147,830	1,120,111
	5.10	397,552	567,190	147,231	161,566	1,273,539
14.60	3.10	303,924				303,924
	3.50	388,729				388,729
	3.90	388,729	118,096		29,972	536,797
	4.30	388,729	263,769	117,905	104,878	875,281
	4.70	388,729	438,967	146,822	156,846	1,131,364
	5.10	397,552	567,190	160,430	165,436	1,290,608
16.10	3.10	303,924				303,924
	3.50	388,729				388,729
	3.90	388,729		10,238	57,914	456,881
	4.30	388,729	263,769	127,166	123,570	903,234
	4.70	388,729	438,967	145,530	158,592	1,131,818
	5.10	397,552	567,190	160,335	171,336	1,296,413
17.60	3.10	303,924				303,924
	3.50	388,729				388,729
	3.90	388,729				388,729
	4.30	388,729				388,729
	4.70	388,729	433,436	145,530	158,592	1,126,287
	5.10	397,652	510,011	161,028	171,336	1,239,927

[a] Capacity for 35 or more cows per farm.
[b] Capacity for less than 35 cows per farm.
[c] 170 or more crop acres per farm.
[d] Less than 170 crop acres per farm.
[e] In addition, there are in the study area 232 small non-specialized dairy farms with large (170 or more) crop acreage, and 4,062 farms with no dairy facilities. None of these strata were found to be an important source of milk in a relevant range of milk price.

of inputs. Nor does it allow farm-market interaction that arises from the aggregation of optimum milk supplies from individual farms to affect price expectations. Aggregative quantities of milk obtained by this method would not maintain the property of profit-maximizing optimality if interfarm or farm-market interaction occurred.

Specialized dairy farms alone were found to produce milk in optimum plans at milk prices less than $3.90 per hundredweight. However, they produced the same quantity of milk over the entire price range, $3.50 to $4.70, and but little more even at $5.10 per hundredweight.

At $3.90, a small volume is produced on non-specialized small dairy farms (30 million pounds, with hogs priced at $14.60 or less) and a somewhat larger supply from non-specialized dairy farms large in both dairy facilities and crop acres (118 million pounds, with hogs priced at $14.60 or less). At $3.90, the non-specialized large dairy farms with small crop acreage also enter the market with hogs priced at $16.10. Also the small farms increase their milk output at this price, but this addition to total supply is more than offset by the elimination, at $16.10 for hogs, of the non-specialized large dairy farms .

At $17.60 for hogs, only the specialized dairy farms remain in milk production at prices of milk less than $4.70. At this level, a price of $4.70 is required to make milk production competitive with hogs on non-specialized dairy farms.

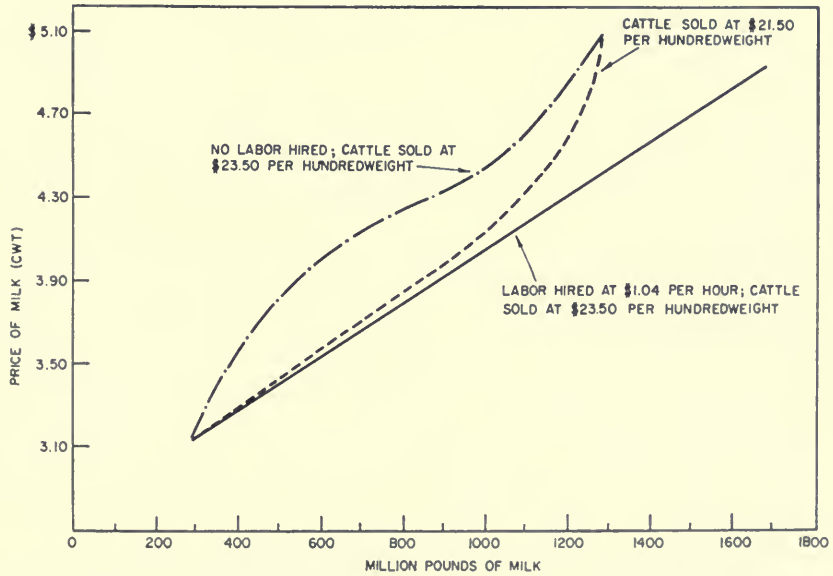
In Table 32 we aggregate the supply response generated under the assumption that labor could be hired at $1.04 per hour. Programmed estimates are confined to specialized dairy farms and to non-specialized dairy farms that are large both in terms of dairy capacity and crop acreage. Estimates of response for large dairy farms on small acreage are adjusted as indicated in Table 32 to yield new area totals. All totals relate to a corn price of $1.08, a hog price of $14.60, and a cattle price of $23.50. Response to the opportunity to hire labor at so low a wage rate is thus seen to generate a substantially increased supply of milk, especially at $4.30 per hundredweight and more for milk.

When the price assumptions were first made for this study, cattle prices were substantially higher than at present. Indeed the size of the intervening price decline was greater than anticipated. Nonetheless, as indicated in Table 29, the price was varied for beef cattle to include $21.50 for fed steers in the case of the large dairy farm with large acreage. This was the type of farm on which cattle feeding was found most important within the relevant ranges of milk and hog prices. Dropping the price of fed cattle to $21.50 had the consequence of increasing the estimated quantity of milk from these farms at $3.90, $4.30 and $4.70 per hundredweight of milk from 118 million, 264 million, and 438 million, respectively, to 233 million, 439 million, and 566 million. All other quantities remain as indicated in Table 31 (column 4). If we

Table 32. — Milk per Year From the Illinois Section of the Chicago Supply Area (Thousand Pounds per Year), Labor Hired at $1.04 per Hour, Hogs Priced at $14.60 per Hundredweight

Price of milk	Specialized dairy farms	Non-specialized dairy farms		Total
		Large dairy, large crop[a]	Other[b]	
Number of farms	1,634	779	787	3,200
		(thousands of pounds per year)		
$3.10	303,924			303,924
3.50	388,729			388,729
3.90	441,180	118,096	29,972	589,248
4.30	545,919	433,436	198,216	1,177,571
4.70	545,919	942,356	315,191	1,803,466
5.10	545,919	999,301	344,404	1,889,624

[a] Capacity for 35 or more cows per farm and with 170 or more crop acres.
[b] Column 6, Table 31 plus Column 5, Table 31 multiplied by the following ratio: production from large dairy farms with large crop acreage and *with* hired labor (Column 3) in the numerator; to production from large dairy farms with large crop acreage *without* hired labor (Column 3, Table 31 with hogs priced at $14.60) in the denominator. This adjustment assumes that large dairy farms respond proportionately the same whether or not the crop acreage is large.



Milk supply at selected prices of milk at varied prices of fed cattle and labor in northeastern Illinois (hogs priced at $14.60). (Fig. 1)

assume that no other milk-producing farm responds to this change in cattle price, the area supply schedule changes from that shown in the last column of Table 31 (at $14.60 for hogs) to the following:

Price of milk	*Pounds of milk (thousands)*
$3.10	303,924
3.50	388,729
3.90	852,137
4.30	1,050,479
4.70	1,259,587
5.10	1,290,608

Area results under the alternate assumptions are summarized in Fig. 1. The response to labor hiring at the low wage of $1.04 is seen to be substantial. At the higher and perhaps more realistic wage rates for this area, the response would still be important but less. Some indication can be obtained by reviewing the effects of varied wage rates on milk output on specialized dairy farms, as shown in Table 23. These results are not aggregated because comparable results are not available for non-specialized dairy farms.

CONCLUSIONS

Within the range of prices considered above, specialized farms accounted for from about one-fourth to all of the total milk supply depending on the level of milk price. Hence the response of this class of farms is especially important in the total milk supply. Our estimates suggest that they are more responsive to changes in wage rates than to changes in the price of either milk or corn.

On the other hand, in response to increases in milk price, the non-specialized farms increased milk output. The increase was especially rapid on non-specialized farms of large size. This conclusion too is important. Farms are becoming larger and fewer. Our results suggest that a certain degree of flexibility and resource organization may well be a consequence, and that the elasticity of milk supply with respect to milk price might well increase. However this result is modified by the associated tendency to specialize — and thus incur some loss in flexibility in response to price change.

A somewhat surprising result of the study is the tendency in resource allocation for milk production and hog production to move together in response to changes in the price of milk and hogs. The reason for this is found in the complex of capital, feed supply, and labor conditions. The tendency is restricted to hog prices of less than

$17.60 per hundredweight. Below this price, hogs and dairy together were competitive with beef cattle. At higher hog prices, all three enterprises were competitive.

The aggregate response of all producers to milk price suggests that in optimum plans, milk supply is fairly elastic with respect to the price of milk. Between $3.90 and $4.70 per hundredweight, under the assumption of a fixed labor supply, the price-elasticity ranges from 2.07 to 3.83, depending on whether fed cattle sell for $21.50 or $23.50 per hundredweight. The opportunity to hire labor increases the price-elasticity of supply. At the low wage rate of $1.04 per hour, the price-elasticity is increased to about 4.05. At more realistic wage rates, the price-elasticity would be increased by the opportunity to hire labor, but to levels probably between 3.0 and 4.0. In any event, with an increase in the price of milk, we would predict a large increase in the output of milk in the Illinois section of the Chicago milk market supply area. Where alternatives are fewer, results will differ from those found in our study.

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